ONE-PIECE FIELD CORE SHELL

FIELD OF THE INVENTION

This invention relates generally to a field core shell typically part of a field core assembly used on an electromagnetic clutch of the type found in automotive air conditioning systems to drive a compressor, and more particularly, to a one-piece field core shell and method of shaping the one-piece field core shell by spin-roll forming.

BACKGROUND OF THE INVENTION

A typical electromagnetic clutch contains an annular electromagnet coil that fits into a wire winding pod section in the field core shell of a field core assembly.

Field core shells have traditionally been manufactured using a two-piece construction. As shown in FIGS. 1A-C, a press formed top angled piece is attached to a press formed annular bottom piece that contains inner and outer rings used to hold the wire windings of the electromagnetic coil. As illustrated in Patent No. 5,273,385, incorporated by reference, an integral blind tubular rivet is used to hold the top angled piece to the bottom piece, forming the completed assembly. This assembly is illustrated in cross-section in FIG. 1C.

Forming a field core shell from a two-piece construction described above and as shown in FIG. 1C is a time consuming and costly process.

The cost of manufacturing two separate components that comprise the shell and the cost of assembling those components, may be reduced by forming a one-piece shell.

References in the automotive art that disclose spin-roll forming products from a single piece of metal include U.S. Patents No. 4,388,817, No. 4,532,786, and No. 4,936,129. Each of these patents discloses a method of forming an automotive wheel from a single piece of metal wherein, during the wheel-forming process, a peripheral portion of the metal preform is split radially to form two annular split portions, which are then formed into different portions of the wheel rim.

The present invention relates to manufacturing a one-piece field core shell by using spin-roll forming methods. A one-piece field core shell that may be used in a field core assembly such as those found on an electromagnetic clutch of the type found in automotive air conditioning systems.

SUMMARY OF THE INVENTION

In accordance with one aspect, the present invention provides for a field core shell made from a single piece of metal typically, a solid circular disk, by a spin-roll forming process. The spin-roll forming process displaces metal from a flat portion (e.g., a flat plate of metal sheet) in a radial and axial direction to produce the one-piece field core shell.

In accordance with another aspect, the present invention provides a spin-roll formed one-piece field core shell that is formed from a disc having top and bottom external surfaces. The core shell has an outer annular ring integral to and encircling a center axis of the disc and extending from the bottom external surface in a direction that is perpendicular to the bottom surface of the disc and parallel to the center axis of the disc. The core shell has an inner annular ring integral to and encircling a center axis of the disc, with the inner annular axis spaced radially inward from the outer annular ring and extending from the bottom external surface in a direction that is perpendicular to the bottom surface of the disc and parallel to the center axis of the disc. The core shell also has a mounting flange integral to the disc, with having a bore extending from the mounting flange to the bottom external surface of the disc.

In accordance with yet another aspect, the present invention provides a method of forming the one-piece field core shell. In the method, a shaping roller is pressed against a side of a spinning annular disc of sheet metal. The shaping roller is moved progressively radially inwardly against the side of the rotating disc which displaces a portion of metal in the form of an axially extending annular wave. The so displaced metal is pressed by an axially moving shaping roller against different mandrels to form a mounting flange and two annular rings opposite the mounting flange to complete the integral one-piece component.

A feature of the invention is to provide a field core shell that is made from a one-piece construction that is less costly and time consuming to manufacture than the current construction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a top perspective view of a prior art field core shell;

FIG. 1B is a bottom perspective view of the core shell of FIG. 1A, and shows installed wire windings;

FIG. 1C is a cross section view taken along line 1C-1C in FIG. 1A;

FIG. 2A is a top perspective view of a first embodiment of a field core shell of the present invention;

FIG. 2B is a bottom perspective view of the first embodiment of the field core shell of the present invention;

FIG. 2C is a cross section view taken along line 2C-2C in FIG. 2A;

FIG. 3A is a top perspective view of a second embodiment of the field core shell of the present invention;

FIG. 3B is a bottom perspective view of the second embodiment of the field core shell of the present invention;

FIG. 3C is a cross section view taken along line 3C-3C in FIG. 3A;

FIG. 4A is a cross section view of a stamped wire winding pod that may be used to make either a first or second embodiment of the field core shell of the present invention;

FIG. 4B is a cross section view of the first embodiment of the field core shell made using the stamped wire winding pod in FIG. 4A, with the mounting flange being spin-roll formed;

FIG. 5 is a cross-section view of key elements of a spin-roll forming machine and an annular disc positioned in the machine for spin-roll forming;

FIG. 6 is a view similar to FIG. 5, but showing a machine at a progressive operational step completing the mounting flange in the first embodiment of the field core shell of the present invention;

FIG. 7 is a view similar to FIG. 5, but showing the machine at a progressive operational step completing the inner annular ring of the first embodiment of the field core shell of the present invention;

FIG. 8 is a view similar to FIG. 5 but showing the machine at a progressive operational step the outer annular ring of the first embodiment of the field core shell of the present invention;

FIG. 9 illustrates the completion of the bore and a hole for wire leads for the first embodiment of the field core shell of the present invention; and

FIGS. 10-13 are cross-section views that illustrate a second method for making the first embodiment of the field core shell of the present invention.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

In order to better appreciate the present invention, the prior art is briefly discussed. Referring now to FIG. 1A-C, a prior art two-piece field core shell **10a** is shown having an outer annular ring **26a** and an inner annular ring **24a** that form a wire winding pod **20a.** Using multiple components, a separately formed mounting flange **30a** is attached to the wire winding pod **20a** by rivets **14a** using a number of manufacturing operations.

A first embodiment of a one-piece field core shell **10** shown in FIGS. 2A-C is produced from a blank disc of sheet metal. The first embodiment includes a spin-roll formed wire winding pod **22** having an outer annular ring **26,** an inner annular ring **24** and a top surface **25.** The top surface **25** having a hole **18** to feed wire leads. The mounting flange **30** is spin-roll formed completing the one-piece field core shell **10** of the first embodiment of the present invention.

A first method for forming the first embodiment of the present invention formed from a blank disc of sheet metal is shown in progressive steps in FIGS. 5-9 and will now be described.

Referring to FIG. 5, a spin-roll forming machine **40** is shown in an initial run position where the blank disc is starting to be shaped in a form that, when finished, includes the features of the first embodiment of the present invention.

Machine **40** is a versatile piece of equipment that can accommodate mandrels that may form a range of mounting flanges and wire winding pod diameters according to the methods of the present invention. Mandrels are selected and used having the required corresponding diameters needed to form the appropriate mounting flanges and wire winding pods as desired by the field core shell machine operator.

The machine **40** includes a headstock mandrel **42** and a mounting flange forming mandrel **44**. A solid circular disc **50** of sheet metal is positioned within a circular recess **56** on the headstock mandrel **42** and is securely clamped thereto by an end face **46** of mounting flange forming mandrel **44**. The mounting flange forming mandrel **44** is moved in *an axial* direction D and pressed firmly against the center of disc **50** to hold it in position during the forming process.

A shaping roller **48** is transferred to an initial forming position by moving it in the X direction so that a rounded edge **49** of the shaping roller is pressed against the disc **50**. The mandrel and head stock are rotated which spins the disc around an axis A. Shaping roller **48** is also free to rotate around axis B as the disc spins. The shaping roller **48** with its rounded edge **49** moves progressively in direction X from edge **54** (FIG. 5) against the upper face **52** of the disc and displaces metal along the upper face of the disc and thins the disc while forming mounting flange **30**

(FIG.6) to a desired height and diameter, for example, as is shown in FIG. 6.

The one-piece field core shell, with its mounting flange **30** formed, is taken from the mandrel **42** and inverted 180 degrees and placed onto a mounting flange mandrel **44** (FIG. 7). The mounting flange mandrel **44** holds the partially formed one-piece field core for its next operation. As shown in FIG. 7, the inner annular ring **24** is now spin-roll formed by shaping roller **48**. Mounting flange **30** is pressed firmly into mounting flange mandrel **44**, while the partially formed one-piece field core shell is securely clamped by end face **63** of inner annular ring forming mandrel **62**. Mounting flange **30** spins about axis A in spin-roll forming machine **40** while the shaping roller **48** is again, as shown in FIG. 5, brought into contact with an upper face **52** of disc **50** at a position proximate the edge **54** of disc **50**. The shaping roller **48**, with its rounded edge **49**, moves progressively in direction X against the side of the disc and displaces metal from the side of the disc and thins the disc while forming the inner annular ring **24** to a desired height and diameter, for example as shown in FIG. 7.

Once the inner annular ring **24** is formed, the one-piece field core shell is ready for its final operations. (FIGS. 8 and 9). The one-piece field core shell with its mounting flange **30** and inner annular ring **24** formed, is taken from mandrel **44** and again inverted 180 degrees and placed onto outer annular ring mandrel **61**(FIG. 8). Mandrel **44** and outer annular ring mandrel **61** hold the part in spin-roll forming machine **40** while outer

annular ring forming tool **64** moves in the X direction contacting edge **58** as shown in FIG. 7, moving edge **58** in the D direction forming outer annular ring **26** to a desired height and diameter, for example as shown in FIG. 8.

As shown in FIG. 9, the bore **16**, used to mount a shaft (not shown) and access hole **18** for the lead wires of the wire windings are then formed using tools **35, 36**. The tools may be devices such as a drill or punch or any other tool that can pierce sheet metal. The above-described method of forming the first embodiment from a blank disc of sheet metal thus produces the less costly and easily manufactured spin-roll formed field core shell of the present invention.

A second method of forming the first embodiment is shown in FIGS. 10-13. An annular disc **51** with a center hole **57** is placed in machine **40** as shown in FIG. 10. A mounting flange **30** and bore is formed using tool **33** by the application of force to a desired height and diameter, for example, as shown in FIG.11.

As shown in FIG. 12, the inner annular ring **24** is now spin-roll formed by shaping roller **48**. Mounting flange **30** is pressed firmly into mounting flange mandrel **44**, while the partially formed one-piece field core shell is also securely clamped in inner annular ring forming mandrel **62**. Mounting flange **30** spins about axis A in spin-roll forming machine **40** while the shaping roller **48** is brought into contact with an upper face **52** of disc **51** at a position proximate the edge **54** of disc **51**. The shaping roller **48**,

with its rounded edge **49**, moves progressively in direction X against the side of the disc and displaces metal from the side of the disc and thins the disc while forming the inner annular ring **24** to a desired height and diameter, for example, as shown in FIG. 12.

Once the inner annular ring **24** is formed, the one-piece field core shell is ready for its final operation (FIG. 13). The one-piece field core shell with its mounting flange **30** and inner annular ring **24** formed, is taken from mandrel **44** and inverted 180 degrees and placed onto outer annular ring mandrel **61** (FIG. 13). Mandrel **44** and outer annular ring mandrel **61** hold the part in spin-roll forming machine **40** while outer annular ring forming tool **64** moves in the X direction contacting edge **58** (FIG. 12), moving edge **58** in the D direction forming outer annular ring **26** to a desired height and diameter, for example, as shown in FIG. 13. Similar to the process step in FIG. 9, the access hole **18** for the leads for the wire winding is then formed using tool **36**.

The first embodiment of the one-piece field core shell **10** of the present invention as shown in FIGS. 2A-C, may also be produced by using a pre-stamped wire winding pod **21** as shown in FIG. 4A. The stamped wire winding pod **21** has outer annular ring **26** and inner annular ring **24** already formed. Stamped wire winding pod **21** is made in a separate operation and is used in place of the spin-roll formed wire winding pod **22**. The stamped wire winding pod **21**as shown in FIG. 4B, is placed in machine **40** and as explained below, the mounting flange **30** is spin-roll formed to a

desired height and diameter, for example, as shown in FIG. 4B. A bore **16** and access hole **18** for the lead wires of wire windings are also added as shown in FIGS. 2A and 2C.

The method for forming the first embodiment using the stamped wire winding pod **21** of the present invention will now be described with reference to FIG. 4B. The stamped wire winding pod **21** having a top surface **28** is positioned in the spin-roll forming machinery **40** that includes the mounting flange mandrel **44**, a stamped wire winding pod mandrel **41** and a shaping roller **48**. The shaping roller **48** with its rounded edge **49** displaces a portion of metal from the top surface **28** of the stamped wire winding pod **21** which is supported in mandrel **41**.

The shaping roller **48** is transferred to an initial forming position by moving it in direction X so that a rounded edge **49** of the shaping roller is pressed against the disc. The shaping roller **48** with its rounded edge **49** moves progressively in direction X against the top surface **28** of the disc and displaces metal along the upper face of the disc and thins the disc while forming mounting flange **30** to a desired height and diameter, for example, as is shown in FIG. 4B. Similar to the process step in FIG. 9, the bore **16** and access hole **18** for the leads for the wire windings are formed.

Referring now to FIGS. 3A-C, a second embodiment of the one-piece field core shell **11**, has a mounting flange that extends parallel to the top surface **34**. The second embodiment is also produced from a blank sheet of sheet metal. The second embodiment includes a spin-roll

formed wire winding pod **22**, having an outer annular ring **26** and an inner annular ring **24** and holes **18**, **19** on the top surface **34** to feed wire leads.

A method for forming the second embodiment of the one-piece field core, as discussed in the paragraph immediately above, follows in the paragraph below. The equipment and methods used to form the second embodiment are similar to the equipment and methods used to form the first embodiment as previously described and illustrated by FIGS. 5-13. The description of the method used to form the second embodiment below will not include any reference to any particular figures cited above.

To form the second embodiment, the spin-roll forming machine **40** first utilizes the inner annular ring forming mandrel **62**. A solid circular disc **50** of sheet metal is positioned within a circular recess **56** on the headstock mandrel **42** and is securely clamped thereto by an end face **46** of inner annular ring forming mandrel **62**. The inner annular ring forming mandrel **62** is moved in an axial direction D and pressed firmly against the center of disc **50** to hold it in position during the forming process.

A shaping roller **48** is transferred to an initial forming position by moving it in direction X so that a rounded edge **49** of the shaping roller is pressed against the disc. The mandrel and head stock are rotated which spins the disc around an axis A. Shaping roller **48** is also free to rotate as the disc spins. The shaping roller **48** with its rounded edge **49** moves progressively in direction X from edge **54** against the upper face **52** of the

disc and displaces metal along the upper face of the disc and thins the disc while forming inner annular ring **24** to a desired height and diameter.

Once the inner annular ring **24** is formed, the second embodiment of the one-piece field core shell is ready for the outer annular ring **26** to be formed. The one-piece field core shell with its inner annular ring **24** formed, is taken from mandrel **44** and inverted 180 degrees and placed onto outer annular ring mandrel **61**. Mandrel **44** and outer annular ring mandrel **61** hold the part in spin-roll forming machine **40** while outer annular ring forming tool **64** moves in the X direction contacting edge **58**, moving edge **58** in the D direction forming outer annular ring **26** to a desired height and diameter.

Once the outer annular ring **26** is formed, the second embodiment of the one-piece field core shell is ready for its final operation. The center of the circular disk is removed, forming a mounting flange **32** as shown in FIG. 3A. Also similar to the process step in FIG. 9, the access holes **18, 19** for the leads for wire winding are formed.

The inner and outer annular rings of each embodiment of the field core shell as described, may be tapered at an angle alpha (FIG. 2C) in order to allowing the wire windings to enter the wire winding pod formed by the field core shell's annular rings. The tapered angle alpha may be from 0 to 3 degrees from an axis that is parallel to the center axis A of the field core shell as shown in FIG. 2C.

In addition, the inner and outer annular rings of each embodiment of the field core shell as described, extend in a direction that is perpendicular to the bottom surface of the disc and parallel to the center axis of the disc and may be the same distance or one ring may extend farther than the other in length in order to completely capture the wire windings once installed in the field core shell's wire winding pod.

It will be understood by one who is skilled in the art of field cores that a range of mounting flanges and wire winding pod diameters can be provided according to the methods of the present invention by selecting mandrels having the required corresponding diameters to the appropriate mounting flanges and wire winding pods desired.

It is also understood by one who is skilled in the art of spin-roll forming that the order of steps taken to spin-roll form may be reduced or altered from those described above to produce the equivalent one-piece field core shell of the present invention. Also, many types of forming methods equivalent to the spin-roll forming method may be used to produce the desired one-piece field core shell of the present invention. The present invention includes all such equivalent steps and forming methods, and is limited only by the scope of the claims.

Although the invention has been shown and described with respect to certain embodiments, it is obvious that equivalent alterations and modifications will occur beyond those discussed to others skilled in the art upon reading and understanding of the specification. The present

invention includes all such equivalent alterations and modifications, and is limited only by the scope of the claims.